Apprenticeship and Industry Training

Instrument Technician

Apprenticeship Course Outline

3110 (2010)

Government of Alberta

Apprenticeship and Industry Training

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Instrument Technician
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Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Instrument Technician Provincial Apprenticeship Committee.

The graduate of the Instrument Technician apprenticeship program is a certified journeyperson who will be able to:

- have a thorough appreciation of the operating processes and their interrelation-ship with instrumentation.
- have a thorough knowledge of precision measurement and calibration.
- have a comprehensive understanding of basic ac and dc electrical components and circuits in order to do adjustments and repairs of electronic equipment.
- be familiar with the technologies of Electronics, Pneumatics, Hydraulics, Mechanics and Chemistry.
- use the correct and safe method of connecting and disconnecting low voltage signal lines from electronic instruments.
- understand the monitoring processes involved in process quality control.
- master the basic knowledge for the repair, fabrication and assembly of electronic and mechanical assemblies; with complete ability in making pneumatic, hydraulic and process joints and seals.
- exercise good judgement and resourcefulness in construction, maintenance and Occupational Health and Safety.
- perform assigned tasks in accordance with quality and production standards required by industry.

Apprenticeship and Industry Training System

Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The Board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The Board also provides advice to the Minister of Advanced Education and Technology on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member Board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

Provincial Apprenticeship Committees (PAC)

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- Make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

Instrument Technician PAC Members at the Time of Publication

Mr. John Both	Athabasca	Presiding Officer
Mr. Dan Warren	Fort Saskatchewan	Employer
Mr. Drew Pritchard	Lloydminster	Employer
Mrs. Nancy Pinksen	Fort McMurray	Employer
Mr. Chris Charmont	Drumheller	Employer
Mr. Ken Adams	Red Deer	Employee
Mr. Terry Bernard	Calgary	Employee
Mr. Grant Fisher	Stony Plain	Employee

Alberta Government

Alberta Advanced Education and Technology works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Technical Institutes and Colleges

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education and Technology to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board fully supports safe learning and working environments and encourages the teaching of proper safety procedures both within trade specific training and in the workplace.

Trade specific safety training is an integral component of technical training, while ongoing or general non-trade specific safety training remains the responsibility of the employer and the employee as required under workplace health and safety legislation.

Workplace Responsibilities

The employer is responsible for:

- training employees and apprentices in the safe use and operation of equipment
- providing and maintaining safety equipment, protective devices and clothing
- enforcing safe working procedures
- providing safeguards for machinery, equipment and tools
- observing all accident prevention regulations

The employee and apprentice are responsible for:

- working in accordance with the safety regulations pertaining to the job environment
- working in such a way as not to endanger themselves, fellow employees or apprentices

Workplace Health and Safety

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Workplace Health and Safety (Alberta Employment, Immigration and Industry) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.worksafely.org

Technical Training

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The following institutions deliver Instrument Technician apprenticeship technical training:

Grande Prairie Regional College	First Period
Lakeland College	First and Second Period
Northern Alberta Institute of Technology	All Periods
Red Deer College	First and Second Period
Southern Alberta Institute of Technology	All Periods

Procedures for Recommending Revisions to the Course Outline

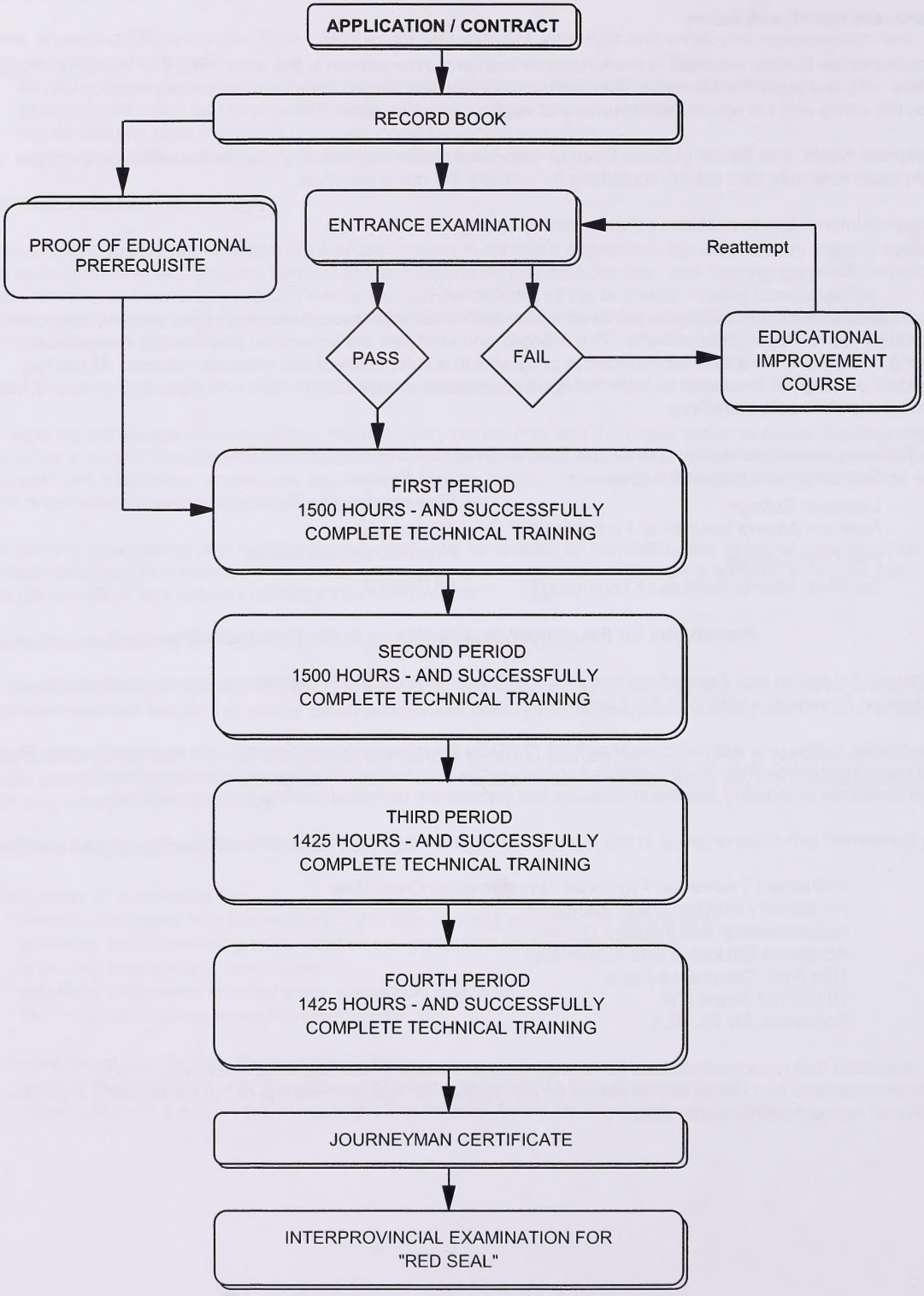
Advanced Education and Technology has prepared this course outline in partnership with the Instrument Technician Provincial Apprenticeship Committee.

This course outline was approved on March 19, 2010 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Instrument Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education and Technology
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Instrument Technician Provincial Apprenticeship Committee.


APPLICATION / CONTRACT
RECORD BOOK
PROOF OF EDUCATIONAL PREREQUISITE
ENTRANCE EXAMINATION
Reattempt
PASS
FAIL
EDUCATIONAL IMPROVEMENT COURSE
FIRST PERIOD
1500 HOURS - AND SUCCESSFULLY COMPLETE TECHNICAL TRAINING
SECOND PERIOD
1500 HOURS - AND SUCCESSFULLY COMPLETE TECHNICAL TRAINING
THIRD PERIOD
1425 HOURS - AND SUCCESSFULLY COMPLETE TECHNICAL TRAINING
FOURTH PERIOD
1425 HOURS - AND SUCCESSFULLY COMPLETE TECHNICAL TRAINING
JOURNEYMAN CERTIFICATE
INTERPROVINCIAL EXAMINATION FOR "RED SEAL"

Instrument Technician Training Profile
FIRST PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

SAFETY, SHOP PRACTICES, THEORY AND LABORATORY

48 HOURS

A	B	C
Introduction to Apprenticeship, Safety and Occupation Skills 7 Hours	Basic Tools 4 Hours	Tube Bending Tube Joining 16 Hours
D	**E**	**F**
Pipe Threading and Joints 9 Hours	Mounting and Support Hardware 6 Hour	Precision Measurement 2 Hours
G		
Electrical and Electronic Connections 4 Hours		

SECTION TWO

ELECTRICAL THEORY AND SAFETY

86 HOURS

A	B	C
Current, Voltage and Resistance 6 Hours	Characteristics of Conductors 2 Hours	Resistors 4 Hours
D	**E**	**F**
Series Resistive Circuits 6 Hours	Parallel Resistive Circuits 6 Hours	Series/Parallel Resistive Circuits 8 Hours
G	**H**	**I**
Work, Energy, Power and Efficiency 6 Hours	Cells and Batteries 4 Hours	Magnetism, Electromagnetism and Electromagnetic Induction 5 Hours
J	**K**	**L**
Fundamentals of Alternating Current (ac) 6 Hours	Inductance and Inductive Reactance 5 Hours	Capacitance and Capacitive Reactance 3 Hours
M	**N**	**O**
Time Constants 6 Hours	Regulations 3 Hours	Area Classifications 4 Hours
P		
Electrical Equipment in Hazardous Locations 12 Hours		

SECTION THREE

BASIC MEASUREMENTS AND CALIBRATION

33 HOURS

A	B	C
Pressure Measurement 5 Hours	Link and Lever Systems 4 Hours	Pressure Gauges 5 Hours
D	**E**	**F**
Pressure Regulators 4 Hours	Pneumatic Components and Feedback Systems 5 Hours	Pressure Transmitters 6 Hours
G		
Chart Recorders 4 Hours		

SECTION FOUR

FINAL CONTROL ELEMENTS

33 HOURS

A	B	C
Reciprocating Control Valves 6 Hours	Rotary Control Valves 6 Hours	Actuators 8 Hours
D	**E**	**F**
Valve Positioners 4 Hours	Control Valve Selection 4 Hours	Control Valve Servicing 5 Hours

SECTION FIVE

RELATED APPLIED PHYSICS AND MATHEMATICS

40 HOURS

A	B	C
SI and Imperial Units and Basic Mathematics 4 Hours	Motion and Force 5 Hours	Pressure 2 Hours
D	**E**	**F**
Work and Power 4 Hours	Energy 4 Hours	Fluid Principles 7 Hours
G	**H**	**I**
Heat and Temperature 7 Hours	Laws of Perfect Gases 3 Hours	Solids 4 Hours

SECOND PERIOD
(8 Weeks/30 Hours Per Week –Total Of 240 Hours)

SECTION ONE

MEASUREMENT INSTRUMENTS
70 HOURS

A	B	C
Temperature Measurement 8 Hours	Thermometers and Filled Thermal Systems 4 Hours	Thermocouples 10 Hours
D	**E**	**F**
RTD's and Thermistors 8 Hours	Non Contact Temperature Measurement 4 Hours	Flow Measurement Fundamentals 3 Hours
G	**H**	**I**
Differential Pressure Measurement 4 Hours	Differential Pressure Flow Measurement 9 Hours	Variable Area Meters / Weirs / Flumes / Flow Switches 4 Hours
J	**K**	
Level Measurement 9 Hours	Differential Pressure Level Measurement 7 Hours	

SECTION TWO

CONTROL INSTRUMENTS
36 HOURS

A	B	C
Introduction to Automatic Control 6 Hours	On-Off Controllers 4 Hours	PID Control 14 Hours
D		
Pneumatic Controller Tuning 12 Hours		

SECTION THREE

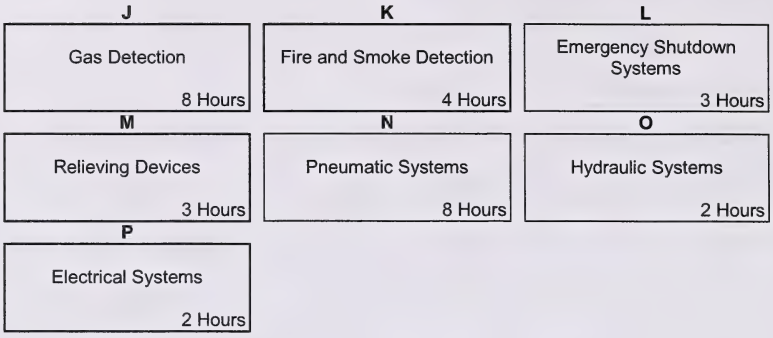
ELECTRICAL AND DIGITAL FUNDAMENTALS
61 HOURS

A	B	C
Electrical Theory 7 Hours	Power Supplies 6 Hours	Introduction to Digital 5 Hours
D	**E**	**F**
Logic Gates 3 Hours	Microprocessor and Memory 2 Hours	Introduction to Programmable Logic Controllers (PLC) 18 Hours
G	**H**	**I**
Introduction to Data Communications 10 Hours	Introduction to Personal Computers 2 Hours	Office Applications 4 Hours
J		
Industrial Software Applications 4 Hours		

SECTION FOUR

PROCESS EQUIPMENT AND ENERGY SYSTEMS
73 HOURS

A	B	C
Drawings and Symbols 6 Hours	Gas Compression 8 Hours	Liquid Pumping 4 Hours
D	**E**	**F**
Solids and Liquids 4 Hours	Heat Transfer and Evaporation 5 Hours	Drying, Humidification and Dehumidification 5 Hours
G	**H**	**I**
Distillation and Fractionation 3 Hours	Boilers and Direct Fired Heaters 3 Hours	Production and Processing Plants 5 Hours


J
Gas Detection
8 Hours
K
Fire and Smoke Detection
4 Hours
L
Emergency Shutdown Systems
3 Hours
M
Relieving Devices
3 Hours
N
Pneumatic Systems
8 Hours
O
Hydraulic Systems
2 Hours
P
Electrical Systems
2 Hours

THIRD PERIOD
(10 Weeks 30 Hours per Week – Total of 300 Hours)

SECTION ONE

ELECTRONIC INSTRUMENT LOOPS
43 HOURS

A	B	C
Analog Loops 10 Hours	Grounding and Shielding Methods 8 Hours	Analog to Digital and Digital to Analog Conversion 4 Hours
D	**E**	**F**
Signal Conditioning 6 Hours	Smart Instruments 10 Hours	Single Loop Digital Controllers 5 Hours

SECTION TWO

MEASUREMENT
74 HOURS

A	B	C
Accuracy and Repeatability 9 Hours	Measurement Traceability 4 Hours	Differential Pressure 4 Hours
D	**E**	**F**
Nuclear 3 Hours	Ultrasonic and Radar 5 Hours	Capacitance/Thermal Dispersion/Optical/ Magnetostrictive 5 Hours
G	**H**	**I**
Solids 2 Hours	Flow Measurement 4 Hours	Differential Pressure Elements 3 Hours
J	**K**	**L**
Magnetic Flow Meters 3 Hours	Turbine Flow Meters 6 Hours	Vortex Flow Meters 3 Hours
M	**N**	**O**
Ultrasonic Flow Meters 3 Hours	Mass Flow Meters 6 Hours	Positive Displacement 6 Hours
P		
Flow Computers 8 Hours		

SECTION THREE

PHYSICAL PROPERTIES
66 HOURS

A	B	C
Matter 9 Hours	Inorganic Compounds 8 Hours	Chemical Calculations 8 Hours
D	**E**	**F**
Chemical Reaction 12 Hours	Organic Chemistry 15 Hours	Viscosity 2 Hours
G		
Metallurgy 12 Hours		

SECTION FOUR

PROCESS ANALYZERS
48 HOURS

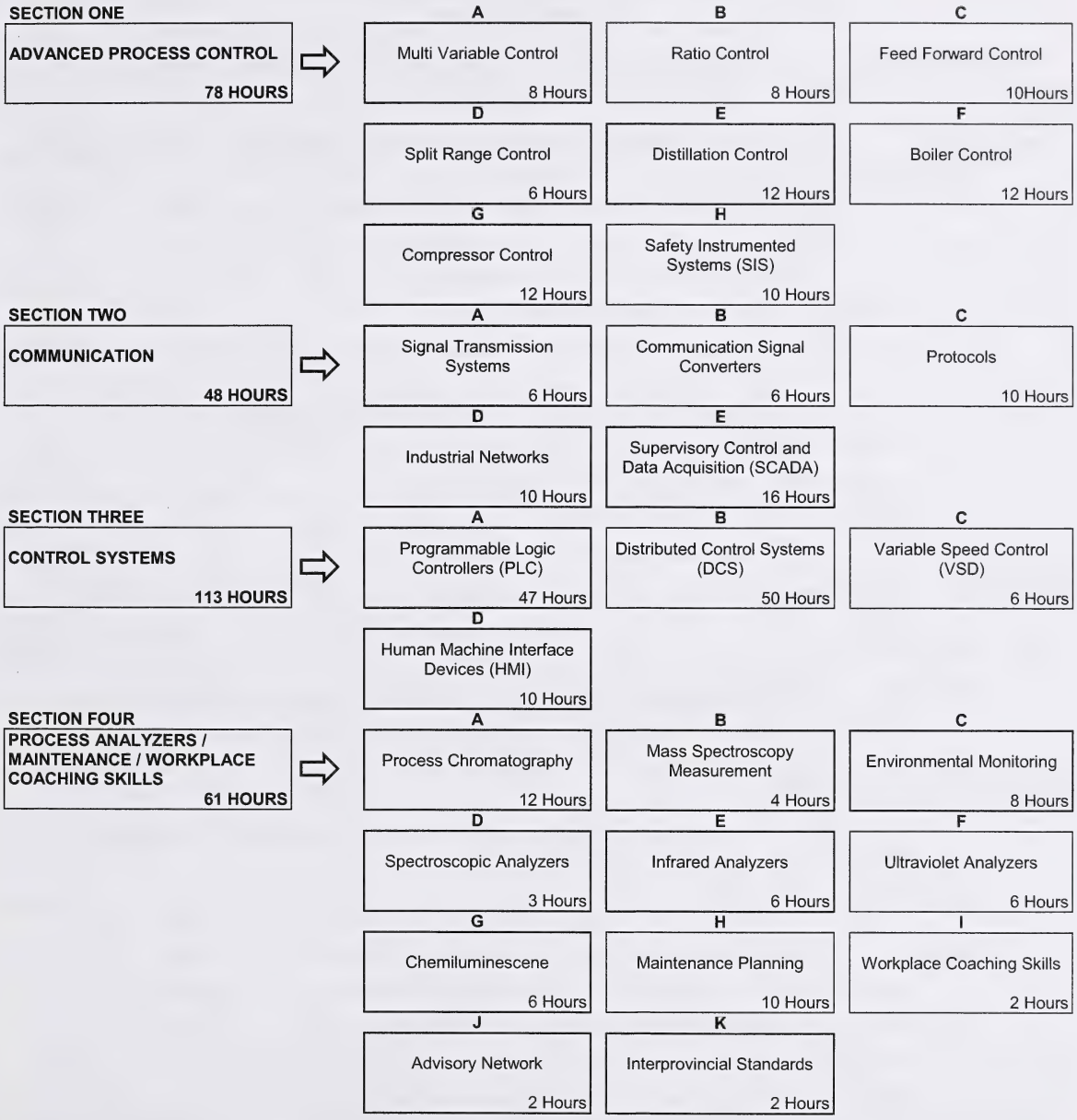
A	B	C
Process Analyzers 6 Hours	Analyzer Sampling Systems 8 Hours	Gas Analyzers 12 Hours
D	**E**	**F**
Liquid Analyzers 12 Hours	Physical Property Analyzers 6 Hours	Vibration Monitoring 4 Hours

SECTION FIVE

PROCESS CONTROL
69 HOURS

A	B	C
Closed Loop Control 16 Hours	Process Loop Dynamics 16 Hours	Control Loop Analysis 10 Hours
D	**E**	**F**
Digital Controller Tuning 10 Hours	Cascade Control 10 Hours	Selective Control 7 Hours

FOURTH PERIOD
(10 Weeks/30 Hours Per Week –Total Of 300 Hours)



NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

FIRST PERIOD TECHNICAL TRAINING
INSTRUMENTATION TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... SAFETY, SHOP PRACTICES,THEORY AND LABORATORY ..... 48 HOURS

A. Introduction to Apprenticeship, Safety and Occupation Skills ..... 7 Hours

Outcome: ***Describe apprenticeship, safe work practices, safety procedures and responsibility for safety in the workplace.***

1. Describe the apprenticeship training system in Alberta.
2. Describe the workplace safety programs in Alberta and safety procedures relating to the Instrument Technician trade.
3. Identify workplace hazards, employ hazard assessments and risk mitigation.
4. Describe emergency procedures when dealing with injured employees.
5. Describe various energy isolation procedures and applications.
6. Demonstrate an awareness of OH&S.
7. Demonstrate an awareness of WHMIS.
8. Demonstrate requirements related to personal protective equipment and safety measures.

B. Basic Tools ..... 4 Hours

Outcome: ***Demonstrate appropriate selection and use of various hand and power tools.***

1. Describe and apply safe techniques for using various workshop hand tools and power tools.
2. Demonstrate the safe use of common hand tools and equipment related to the instrument technician trade.
3. Demonstrate the safe use of common power and specialty tools related to the instrument technician trade.

C. Tube Bending and Tube Joining ..... 16 Hours

Outcome: ***Perform tube jointing and tube bending procedures.***

1. Identify the different types and sizes of tube and tube fittings.
2. Identify common tools and techniques used in tube jointing.
3. Identify common tools and techniques used in tube bending.
4. Identify hazards associated with tube and fitting selection and installation.
5. Calculate tube bending lengths for various tube configurations and angles.
6. Demonstrate tube bending for instrument installations.
7. Design and install raceway to support tubing.
8. Install tubing and tube fittings for safe leak proof installations.
9. Demonstrate the use of common tools used in jointing tube.
10. Demonstrate soft soldering techniques for joining copper tube.

D. Pipe Threading and Joints ..... 9 Hours

Outcome: ***Demonstrate pipe threading and pipe jointing procedures for various applications.***

1. Identify the different types and sizes of pipe, fittings and flanges.
2. Identify hazards associated with pipe and fitting selection and installation.
3. Explain tools used in pipe jointing.
4. Explain how to achieve a pipe installation emphasising threaded pipe joints.
5. Demonstrate threading of steel pipe with the use of power threaders and hand threaders.
6. Install threaded pipe and fittings for a safe leak tight installation.
7. Install flange connections for a safe leak tight installation

E. Mounting and Support Hardware ..... 6 Hours

Outcome: ***Fabricate and install mounting and support hardware.***

1. Describe mounting and support hardware and applications.
2. Explain mounting hardware location considerations and limitations.
3. Identify tools commonly used in mounting and support hardware.
4. Fabricate mounting and support hardware.
5. Install mounting and support hardware

F. Precision Measurement ..... 2 Hours

Outcome: ***Use precision measuring instruments.***

1. Describe precision measurement used in dimensional measurement.
2. Describe measuring instruments used for precision measurement.
3. Demonstrate techniques for using precision measuring instruments.

G. Electrical and Electronic Connections ..... 4 Hours

Outcome: ***Assemble electrical and electronic connections.***

1. Describe the tools, materials, and techniques used for soldering electronic circuits.
2. Describe methods used in electrical connections and their importance.
3. Describe static and anti-static devices.
4. Demonstrate electrical connection techniques.
5. Desolder and remove components from printed circuit boards.
6. Install and solder electronic components onto a printed circuit board.

SECTION TWO: ..... ELECTRICAL THEORY AND SAFETY ..... 86 HOURS

A. Current, Voltage, and Resistance ..... 6 Hours

Outcome: ***Define voltage, current and resistance.***

1. Describe an electric current.
2. Describe voltage.
3. Describe resistance and state and apply Ohm's law.

B. Characteristics of Conductors ..... 2 Hours

Outcome: ***Describe conductors, semiconductors and insulators.***

1. Describe the factors affecting resistance.
2. Calculate the resistance of a conductor of specific dimensions.
3. Describe the electrical properties of materials.

C. Resistors ..... 4 Hours

Outcome: ***Identify various resistors.***

1. List two categories of resistors and describe their construction.
2. Explain the methods used to determine the ratings of fixed resistors.
3. Use a colour code chart to determine the resistance of a resistor.
4. Connect and verify relationship between voltage, current and resistance according to Ohm's law.

D. Series Resistive Circuits ..... 6 Hours

Outcome: ***Connect and analyze a series resistive circuit.***

1. Define a series circuit and calculate current in a series circuit.
2. State the formula for total resistance and calculate resistance in a series circuit.
3. State and apply Kirchhoff's voltage law to a series circuit.
4. Define the terms ratio and direct proportion and perform calculations using both.
5. State the relationship between the resistive values of components and their voltage drops and solve problems using the voltage divider rule.
6. Determine the voltage drop across a closed or open-circuit component in a series circuit.
7. Connect and verify Kirchhoff's current and voltage laws in a series resistive circuit.

E. Parallel Resistive Circuits ..... 6 Hours

Outcome: ***Connect and analyze a parallel circuit.***

1. Define a parallel circuit.
2. Calculate the total resistance of a parallel circuit using the appropriate formulas.
3. State and apply Kirchhoff's current law to a parallel circuit.
4. Describe the effects of open circuits on a parallel circuit.
5. Use the current divider principle to calculate branch currents.
6. Connect and verify Kirchhoff's current laws in a parallel resistive circuit.

F. Series-Parallel Resistive Circuits ..... 8 Hours

Outcome: ***Connect and analyze a series-parallel resistive circuit.***

1. Identify resistors that are in series.
2. Identify resistors that are in parallel.
3. Calculate the total resistance of a series-parallel circuit.
4. Apply Kirchhoff's current law.
5. Apply Kirchhoff's voltage law.

6. Solve problems involving series-parallel circuits.
7. Connect and verify the relationship of current, voltage and resistance in each part of a series/parallel circuit.

G. Work, Energy, Power and Efficiency .....6 Hours

Outcome: ***Describe how mass, work, force, energy, and power are interrelated mechanically and electrically.***

1. Describe mass, weight and force.
2. Describe work, energy and power.
3. Describe electrical relationships of work, energy and power.
4. Calculate efficiency, voltage drop and line loss.
5. Connect an electrical circuit and verify the power formulae.

H. Cells and Batteries.....4 Hours

Outcome: ***Describe cells and batteries.***

1. Define basic terminology of cells.
2. Describe construction and operation of a basic primary cell.
3. Describe construction and operation of types of lead-acid batteries.
4. Describe construction and operation of a nickel-cadmium battery.
5. Describe construction and operation of a lithium battery.
6. Describe hazards and precautions to be observed when charging batteries.
7. Describe common battery performance ratings.
8. Determine the effects of battery internal resistance.

I. Magnetism, Electromagnetism and Electromagnetic Induction .....5 Hours

Outcome: ***Describe magnetism, electromagnetism and electromagnetic induction.***

1. Describe the properties of magnetic materials.
2. Define terminology related to magnetism.
3. Describe electromagnetism and basic design considerations for electromagnetic devices.
4. Describe how an induced voltage is generated.
5. Describe the process of electromagnetic induction.

J. Fundamentals of Alternating Current (ac).....6 Hours

Outcome: ***Describe the fundamental characteristics of ac circuits.***

1. Explain the generation of an ac sine wave.
2. Determine the output frequency of an ac generator.
3. Calculate standard ac sine wave values.
4. Demonstrate the relationship between sine waves and phasor diagrams.
5. Describe the factors affecting impedance in an ac circuit.

K. Inductance and Inductive Reactance ..... 5 Hours

Outcome: ***Apply the concepts of inductance and induction to dc and ac circuits.***

1. Describe a basic inductor (coil).
2. Describe inductance and the factors which affect it.
3. Describe induction and its effects.
4. Describe the effects of an inductor in a dc circuit.
5. Describe the effects of an inductor in an ac circuit.
6. Analyze an ac inductive circuit.
7. Describe the power relationships in an inductive circuit.
8. Connect and analyze circuits containing inductance.

L. Capacitance and Capacitive Reactance ..... 3 Hours

Outcome: ***Apply the concepts of capacitors and their use in dc and ac circuits.***

1. Define capacitance and describe the construction of a basic capacitor.
2. Describe dielectric strength and state the unit of measurement for electric charge.
3. Calculate the value for the time constant in a dc resistor-capacitor circuit.
4. Analyze an ac capacitive circuit.
5. Describe the power relationships in a capacitive circuit.
6. Describe capacitor types and applications.

M. Time Constants ..... 6 Hours

Outcome: ***Apply the concepts of circuit time constants.***

1. Describe the time effects in selected resistor-capacitor circuits.
2. Describe and illustrate the characteristic charge and discharge waveforms.
3. Describe circuit time constants (tau) and the relationship to the characteristic waveforms.
4. Calculate the instantaneous and steady state voltages in resistor-capacitor circuits.
5. Connect and analyze the existence of capacitive reactance in capacitive circuits and the effects of discharge rate when resistance is changed.

N. Regulations ..... 3 Hours

Outcome: ***Apply electrical regulations.***

1. Describe the Instrument Technician's area of electrical work/responsibility.
2. Describe the role of Safety Codes Act and the Canadian Electrical Code Part 1 and how they relate to the instrumentation field.
3. Describe the role of CSA, NEMA and CUL and how they relate to the instrumentation field.

O. Area Classifications ..... 4 Hours

Outcome: ***Describe the classification of hazardous locations and the general rules that apply to these locations.***

1. Define the specific terms from Section 18 of the Canadian Electrical Code Part 1 that apply to area classifications.
2. Apply the general rules regarding installation and maintenance in hazardous locations.

P. Electrical Equipment in Hazardous Locations ..... 12 Hours

Outcome: ***Apply protection methods for electrical equipment in hazardous areas.***

1. Define the purpose of explosion proof equipment.
2. Define installation requirements for conduit, seals, fixtures and appliances.
3. Describe maintenance procedures for explosion proof enclosures.
4. Describe non-incendive equipment.
5. Describe an intrinsically safe loop.
6. Describe an intrinsically safe loop drawing.
7. Describe the grounding requirements of an intrinsically safe system.
8. Describe results of tests on sample loop shorts, grounds and overload.
9. Describe the role of purging under the CSA and ISA definition.
10. Describe the role of sealing, potting and encapsulating for electrical safety.
11. Define the relationship between explosion proof and intrinsically safe systems.
12. Demonstrate how to install a secondary seal.
13. Select and install an intrinsically safe barrier.

SECTION THREE: ..... BASIC MEASUREMENTS AND CALIBRATION ..... 33 HOURS

A. Pressure Measurement ..... 5 Hours

Outcome: ***Apply the principles of pressure and the standards used to measure pressure.***

1. Describe pressure, pressure units, and pressure standards.
2. Apply the principles of pressure standards to pressure measurement techniques.
3. Describe pressure scales and reference points.
4. Perform pressure calculations.

B. Link and Lever Systems ..... 4 Hours

Outcome: ***Calibrate Link & Lever systems.***

1. Define the terms span, angularity, zero, hysteresis, and deadband as they relate to mechanical systems.
2. Describe the force balance measurement method.
3. Perform calibrations of “Link and Lever” systems.

C. Pressure Gauges .....5 Hours

Outcome: ***Select, calibrate, and install pressure gauges.***

1. Describe the construction, applications and limitations of pressure gauges.
2. Describe the installation and protection methods for pressure gauges.
3. Demonstrate the methods and standards used to calibrate pressure gauges.
4. Demonstrate a method to protect pressure gauges.

D. Pressure Regulators .....4 Hours

Outcome: ***Select, install, and maintain pressure regulators.***

1. Describe the operating principles and applications of regulators.
2. Describe and illustrate the design and differences between: spring-loaded, weight- loaded, and pilot operated regulators.
3. Identify hazards associated with pressure regulator selection and installation.
4. Demonstrate the installation and maintenance of a pressure regulator.

E. Pneumatic Components and Feedback Systems .....5 Hours

Outcome: ***Select, install, and maintain pneumatic components and feedback systems.***

1. Describe the operation and construction of pneumatic pilots.
2. Describe the operation and construction of flapper nozzles.
3. Describe the operation and construction of pneumatic relays.
4. Outline the applications for pneumatic relays.
5. Explain the different types of negative feedback systems used in pneumatic instruments.
6. Describe the safety considerations of pneumatic systems.
7. Outline the specifications and components of pneumatic systems.
8. Describe the benefits and disadvantages of pneumatic systems.
9. Describe alternate gas supplies used in pneumatic systems and related hazards.
10. Demonstrate the calibration of a feedback system.

F. Pressure Transmitters .....6 Hours

Outcome: ***Select, install, and maintain pressure transmitters.***

1. Describe the function and construction of pressure transmitters.
2. Describe analog signal standards.
3. Describe the applications and installation requirements for pressure transmitters.
4. Describe the calibration process and the application of input/output calculations for pressure transmitters.
5. Calibrate pressure transmitters.

G. Chart Recorders ..... **4 Hours**

Outcome: ***Select, install, and maintain chart recorders.***

1. Describe the function and construction of chart recorders.
2. Describe applications and installation requirements for chart recorders.
3. Describe and interpret charts and recording methods for chart recorders.
4. Describe the calibration procedures used on chart recorders.
5. Calibrate chart recorders.

SECTION FOUR: ..... **FINAL CONTROL ELEMENTS** ..... **33 HOURS**

A. Reciprocating Control Valves ..... **6 Hours**

Outcome: ***Select, install, and maintain reciprocating control valves.***

1. Describe the applications and construction of reciprocating control valves.
2. Identify the hazards associated with reciprocating control valves
3. Describe the servicing procedures used on reciprocating control valves.
4. Demonstrate how to service a reciprocating control valve.

B. Rotary Control Valves ..... **6 Hours**

Outcome: ***Select, install, and maintain rotary control valves.***

1. Describe the applications and construction of rotary control valves.
2. Identify the hazards associated with rotary control valves
3. Describe the servicing procedures used on rotary control valves.
4. Demonstrate how to service a rotary control valve.

C. Actuators ..... **8 Hours**

Outcome: ***Select, install, and maintain valve actuators.***

1. Describe the applications and selection of actuators and accessories.
2. Identify the hazards associated with servicing valve actuators.
3. Describe the servicing procedures used on valve actuators.
4. Demonstrate how to service and setup various valve actuators.

D. Valve Positioners ..... **4 Hours**

Outcome: ***Select, install, and maintain valve positioners.***

1. Describe the applications and selection of valve positioners.
2. Describe the features of positioners.
3. Describe valve positioner servicing procedures.
4. Demonstrate the operation and calibration of pneumatic valve positioners.

E. Control Valve Selection ..... 4 Hours

Outcome: ***Explain the variables and procedures used in selecting and maintaining control valves.***

1. Describe the principles of friction, and the coefficient of friction, associated with fluids in motion.
2. Define valve characteristic, valve CV, cavitation, flashing, erosion, corrosion, and specialized trim.
3. Describe the procedures and considerations when determining valve sizes and construction materials.
4. Identify the required "Fail Safe" mode and flow direction when selecting valves for a given application.
5. Describe valve packing materials and applications.

F. Control Valve Servicing ..... 5 Hours

Outcome: ***Maintain and service control valves.***

1. Describe the OH&S requirements for energy isolation.
2. Identify hazards associated with removing a control valve for service.
3. Describe the methods used in isolating control valves for servicing.
4. Demonstrate how to isolate a control valve for service.
5. Install actuator, perform bench set and adjust valve stroke.

SECTION FIVE: ..... RELATED APPLIED PHYSICS AND MATHEMATICS ..... 40 HOURS

A. SI and Imperial Units and Basic Mathematics ..... 4 Hour

Outcome: ***Solve trade related mathematical problems.***

1. Describe SI units, prefixes, and conversions between the SI system and the imperial system.
2. Transpose and solve equations involving: fractions, ratios, proportions, percentages, exponents, algebra, trigonometry and logarithms.
3. Describe units of angular measurement, right angles, obtuse angles, isosceles triangles, equilateral triangles, and the application of Pythagoras's Theorem to right angled triangles.
4. Describe and calculate the perimeter, area, and volume of various objects.

B. Motion and Force ..... 5 Hours

Outcome: ***Solve problems related to motion and force.***

1. Describe velocity, acceleration, displacement, average velocity, average acceleration, momentum, gravitational acceleration, scalar vector quantities, force, and mass.
2. Evaluate and solve problems related to force, mass and acceleration.
3. Describe Newton's three laws of motion, and the law of conservation of motion or momentum.
4. Describe moment of force, moment of torque, balancing of forces on a beam, equilibrium of a lever system, effort, and mechanical advantage.
5. Solve problems related to force balance about a point, and the mechanical advantage of a beam.

6. Describe the mechanical advantage or velocity ratio in terms of diameter or radius of wheels, axles, pulleys, and gears.
7. Solve problems related to speed or rotation of pulleys and gears based on diameter or radius as well as the mechanical advantage of a block and tackle system.
8. Solve problems related to force.

C. Pressure ..... 2 Hours

Outcome: ***Solve problems related to pressure.***

1. Describe static pressure, absolute pressure, gauge pressure, and atmospheric pressure in both SI and Imperial units.
2. Solve problems related to pressure.
3. Solve problems related to force and pressure.

D. Work and Power ..... 4 Hours

Outcome: ***Solve problems related to work and power.***

1. Describe the terms work, power and efficiency and their associated units.
2. Solve problems related to work done based on force and distance data.
3. Solve problems related to power based on force, distance, and time data.
4. Express efficiency in terms of output versus input work and power.

E. Energy ..... 4 Hours

Outcome: ***Solve problems related to energy.***

1. Describe energy, potential energy, kinetic energy, and the units of energy.
2. Describe the forms of energy and their formulae.
3. Describe the relationship between potential and kinetic energy and the laws of conservation of energy.
4. Solve problems related to potential energy based on force and height data, and kinetic energy based on mass and velocity data.

F. Fluid Principles ..... 7 Hours

Outcome: ***Solve problems related to fluids and the flow of fluids.***

1. Describe the following: atom, molecule, element, molecular attraction, cohesion, adhesion, capillary action, compressibility, thermal expansion, density, relative density, and specific volume.
2. Solve problems related to the mass, density, and relative density of liquids and solids.
3. Describe Pascal's Law and pressure head.
4. Solve problems related to pressure, density, and height of a liquid column.
5. Describe Archimedes principle and concept of buoyancy.
6. Solve problems related to objects submerged in liquids.
7. Describe turbulent flow, laminar flow, and the continuity equation.
8. Describe Bernoulli's equation, resistance to flow, and flow turbulence.

G. Heat and Temperature .....7 Hours

Outcome: ***Solve problems related to temperature and the principles of heat and heat transfer.***

1. Describe the relationship between the various temperature scales.
2. Describe temperature, heat, sources of heat energy, specific heat, and the laws of thermodynamics.
3. Describe the molecular theory of heat and heat transfer, and its significance on the change of state of a substance.
4. Describe the coefficient of linear expansion, volumetric expansion, and surface expansion of liquids and solids.
5. Solve problems related to expansion of solids, expansion of liquids, and the changes in heat content of liquids.
6. Describe the laws related to heat, conductors, insulators, and the process of heat transfer through: conduction, convection, and radiation.
7. Describe the steam tables and the following properties: sensible heat, latent heat of fusion, latent heat of evaporation, saturation temperature, and superheat.
8. Solve problems related to heat and heat transfer.

H. Laws of Perfect Gases.....3 Hours

Outcome: ***Solve problems related to ideal gases.***

1. Describe Bolye's Law, Charles' Law and the general gas law, in relation to pressure, temperature, and volume.
2. Solve problems involving gas laws.
3. Describe the principles of gas compressibility and volumetric expansion.

I. Solids .....4 Hours

Outcome: ***Solve problems related to solids.***

1. Define elasticity, stress, strain, Hooke's Law, and Young's Modulus of Elasticity.
2. Define the relationship between elastic limit, yield point, ultimate strength, breaking strength, safe working stress, and factor of safety.
3. Define tensile, compressive, and shear stresses.
4. Solve problems related to stress, force area, and strain.

SECOND PERIOD TECHNICAL TRAINING
INSTRUMENTATION TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:.....MEASUREMENT INSTRUMENTS..... 70 HOURS

A. Temperature Measurement.....8 Hours

Outcome: ***Describe temperature measurement.***

1. Explain why and where temperature measurement is used in industry.
2. Define terms that apply to temperature measurement.
3. Convert temperature readings between scales.
4. Define coefficient of linear, coefficient of area and coefficient of volume expansion.
5. Solve problems involving linear and volumetric expansion of materials.
6. Describe thermal contact and its effect on accuracy and response time.
7. Describe thermowell requirements and applications.
8. Describe direct and indirect temperature measurement.
9. Describe thermal time constants.

B. Thermometers and Filled Thermal Systems.....4 Hours

Outcome: ***Select, install, and maintain thermometers and filled thermal systems.***

1. Describe the operation and characteristics of thermometers and filled thermal systems.
2. Describe the construction and operating principle of a bimetallic thermometer.
3. Describe a filled thermal system as it relates to temperature measurement.
4. Define full compensation and case compensation.
5. List advantages and disadvantages of various SAMA classifications.
6. Describe applications using case and full compensation.
7. Describe installation effects, including head elevation, thermowells and transmission lag.

C. Thermocouples.....10 Hours

Outcome: ***Select, install, and maintain thermocouples.***

1. Explain the principle operation of a thermocouple element.
2. Describe the operation of a thermocouple circuit with reference junction compensation, using the battery equivalent for each point of emf generation.
3. Identify thermocouples and state the materials used for each type and the colour codes used for identification.
4. State the characteristics of each type of thermocouple including their advantages, limitations and application.
5. Describe the most common methods of thermocouple fabrication.
6. Describe the effects of grounded and ungrounded junctions.

7. Describe the methods and components used for thermocouple installation.
8. Demonstrate the fabrication and installation of a thermocouple.
9. Perform the calculations required to measure the temperature at the thermocouple using a meter and the temperature versus thermocouple referenced tables.
10. Perform the calculations required to calibrate a reference junction compensated transmitter using a mV source and the table referenced to 0°C.
11. Calibrate a thermocouple transmitters.
12. Configure and verify the accuracy of an analog thermocouple temperature transmitter.

D. RTD's and Thermistors ..... 8 Hours

Outcome: Select, install, and maintain Resistive Thermal Devices (RTD's) and thermistors.

1. Explain the principle of operation of an RTD.
2. Compare the characteristics of the metals commonly used in RTD's.
3. Calculate the temperature measured given the resistance of an RTD.
4. Describe two, three and four wire RTD measuring circuits.
5. State the characteristics of each type of RTD's including their advantages, limitations and application.
6. Describe the principle of operation of thermistors.
7. Compare positive and negative temperature coefficients.
8. State the characteristics of each type of thermistor including their advantages, limitations and application.
9. Describe the calibration procedure for an RTD transmitter.
10. Configure and verify the accuracy of an analog RTD temperature transmitter.

E. Non Contact Temperature Measurement ..... 4 Hours

Outcome: Select and maintain non contact temperature measurement devices.

1. Describe the principle of operation of a diode used as a temperature detecting device.
2. Describe selected applications of transistors in temperature measurement.
3. Explain the purpose of non-contact temperature measuring devices.
4. Describe the operating principle of non-contact pyrometers.
5. Define terms used in radiation pyrometry.
6. List the advantages and limitations of non-contact temperature measuring devices.
7. Determine emissivity of various surfaces.

F. Flow Measurement Fundamentals ..... 3 Hours

Outcome: Describe flow measurement.

1. Describe the application of flow measurement.
2. Describe measurement units and terms used in flow measurement.
3. Explain the difference between laminar and turbulent flow.
4. Explain the significance of the Reynold's number used to describe flow.
5. Explain the effect of pulsating flow and dampening.

G. Differential Pressure Measurement ..... 4 Hours

Outcome: ***Describe differential pressure measurement.***

1. Describe the theory and application of differential pressure measurement.
2. Describe devices used for differential pressure measurement.
3. Calibrate a differential pressure device.

H. Differential Pressure Flow Measurement ..... 9 Hours

Outcome: ***Select, install, and maintain differential pressure flow measurement devices.***

1. Describe the relationship between differential pressure and flow measurement.
2. Describe the principle of operation, application, and installation of differential pressure flow elements.
3. Describe the design and selection of orifice plates.
4. Describe the requirements for square root extraction and integration.
5. Define the terms velocity head, pressure head, elevation head and discharge coefficient.
6. Calculate flow using a continuity equation and Bernoulli's equation.
7. Calculate the meter factor for an orifice plate.
8. Remove, inspect and reinstall an orifice plate on an online orifice fitting installation.

I. Variable Area Meters / Weirs / Flumes / Flow Switches ..... 4 Hours

Outcome: ***Select, install, and maintain variable area meters, weirs, flumes and flow switches.***

1. Describe the application and principle of operation of variable area meters.
2. Describe the installation requirements.
3. Describe useful range and accuracy with comparison to fixed area orifice meters.
4. Describe the application and principle of operation of weirs and flumes.
5. Describe the application and principle of operation of flow switches.

J. Level Measurement ..... 9 Hours

Outcome: ***Select, install, and maintain level measurement devices.***

1. Describe the application of level measurement in industry.
2. Differentiate between point level and continuous level detection.
3. Differentiate between direct and inferential methods of level measurement.
4. Describe the types, limitations and applications of level guages.
5. Describe the principles and differences between floats and displacers.
6. State Archimedes' principle as applied to floats and displacers.
7. Calculate the buoyancy of a float.
8. Describe the application of a float used for point and continuous level measurement.
9. Calculate the buoyant force of a displacer.
10. Describe the operation of a displacer element for detecting liquid level and interfaces.
11. Describe the principle of a torque tube.
12. Describe the application of a displacer used for point and continuous level measurement

13. List the advantages and disadvantages of float and displacer type level devices.
14. Connect and calibrate a displacer type instrument for continuous level measurement.

K. Differential Pressure Level Measurement ..... 7 Hours

Outcome: ***Select, install, and maintain differential pressure level measurement devices.***

1. Calculate hydrostatic head pressure.
2. Describe the characteristics of purge fluids and seal fluids.
3. Compare methods of measuring level in atmospheric and pressurized vessels.
4. Define the terms zero elevation and zero suppression and range elevation and range suppression.
5. Sketch a zero elevation and a zero suppression application.
6. Describe a calibration procedure for a zero elevation application and calculate span and elevation settings.
7. Describe a calibration procedure of a zero suppression application and calculate span and elevation settings.
8. Describe a bubbler level system including the required supply pressure settings.
9. Describe purge systems used in bubbler level measurement.
10. Connect and calibrate a pneumatic differential pressure transmitter in atmospheric and pressurized vessels.

SECTION TWO: ..... CONTROL INSTRUMENTS ..... 36 HOURS

A. Introduction to Automatic Control ..... 6 Hours

Outcome: ***Describe the fundamentals of automatic control and control terminology.***

1. Explain why automatic control is necessary in process industries.
2. Define the terms used in automatic control.
3. Illustrate and describe feedback control.
4. Describe the methodology of transferring between auto and manual control.
5. Describe the application of auto/manual stations and bumpless transfer.
6. Demonstrate the effect of controller action.

B. On-Off Controllers ..... 4 Hours

Outcome: ***Select, install, and maintain on-off control.***

1. Describe an on-off controller.
2. Describe the applications of on-off control.
3. Describe the operation of a differential gap controller.
4. Construct and commission an on-off control application.

C. PID Control ..... 14 Hours

Outcome: ***Explain the principle and application of Proportional Integral Derivative (PID) control.***

1. Describe the operation of a pure proportional controller.
2. Define the terms used in PID control.

3. Describe bias and offset as applied to proportional control.
4. Explain the effect of gain on offset.
5. Perform controller output calculations for a proportional only controller.
6. State the applications of a proportional controller.
7. State the purpose and application of integral in a controller.
8. Describe the effect of integral on controller stability.
9. Perform controller output calculations for a PI controller.
10. Explain reset wind-up on a controller.
11. Explain anti-reset wind-up and where it must be incorporated.
12. State the purpose and applications of derivative in a controller.
13. Perform controller output calculations for a PD and PID controller.
14. Perform controller output calculations for direct acting and reverse acting controllers.

D. Pneumatic Controller Tuning ..... 12 Hours

Outcome: ***Tune pneumatic controllers.***

1. Explain the term quarter amplitude decay.
2. Describe open loop methods used for controller tuning.
3. Describe the closed loop methods used for controller tuning.
4. Describe controller modes used on typical processes.
5. Explain critically damped tunings.
6. Perform a pneumatic controller alignment and determine controller action and settings for a proportional only controller.
7. Perform a pneumatic controller alignment and determine controller action and settings for a PI controller and perform a bumpless transfer.

SECTION THREE: ..... ELECTRICAL AND DIGITAL FUNDAMENTALS ..... 61 HOURS

A. Electrical Theory ..... 7 Hours

Outcome: ***Describe basic electrical concepts and circuits.***

1. Describe the relationship between resistance, current and voltage.
2. Recognize and determine the value of various components using color codes and numerical identifiers.
3. Calculate the resistances, voltages, and currents in both series and parallel AC and DC circuits using Ohm's Law, voltage divider and Kirchoff's Laws.
4. Perform power calculations for a circuit, given any three of the following: resistance, current, voltage or power.
5. Determine the frequency, period, and voltages of various waveforms from both graphical representations and an oscilloscope display.
6. Evaluate and solve series/parallel circuits containing AC sources, DC sources, resistors, capacitors, and inductors.

7. Describe the characteristics and operation of conductors, insulators, semiconductors, and PN junctions.
8. Describe characteristics of forward and reverse biased Zener diodes in various circuit configurations.

B. Power Supplies ..... 6 Hours

Outcome: ***Select, install, and maintain power supplies.***

1. Define the operation and applications of various power supplies and uninterruptable power supplies (UPS).
2. Define and illustrate the components of a UPS system.
3. Explain the load vs. voltage characteristics of a transformer and how it applies to power supply sizing.
4. Define power supply output quality and quantity.
5. Troubleshoot power supply output qualities.

C. Introduction to Digital ..... 5 Hours

Outcome: ***Apply the fundamentals of digital electronics.***

1. Describe the application of digital circuitry in measurement and control instrumentation, and how they differ from analog devices.
2. Describe the implications of electrostatic protection when servicing electronic devices.
3. Describe the application, similarities and the base conversion methods for decimal, binary, BCD, and hexadecimal number systems.
4. Solve basic arithmetic operations on decimal, binary, BCD, and hexadecimal number systems.

D. Logic Gates ..... 3 Hours

Outcome: ***Describe various digital logic gates, their schematic symbols, and their Boolean functions.***

1. Describe the purpose of digital logic gates.
2. Show the truth tables for various logic gates.
3. Explain the Boolean equations and the truth tables for various logic gates.

E. Microprocessors and Memory ..... 2 Hours

Outcome: ***Describe the basic elements of a microprocessor and application of various memory devices.***

1. Describe Random Access Memory (RAM) and Read Only Memory (ROM) and their applications.
2. Explain memory addressing and device selection/enabling methods.
3. Describe different types of mass storage devices.
4. Illustrate the components of a microprocessor.
5. Describe different microprocessor peripheral Input / Output (I/O) devices.

F. Introduction to Programmable Logic Controllers (PLC) ..... 18 Hours

Outcome: ***Select, install, and maintain PLC's.***

1. Describe the basic components of a modular PLC.
2. Describe the symbols and conventions used in relay ladder logic diagrams.
3. Derive the ladder logic circuit from a logic gate.
4. Illustrate the ladder logic diagram equivalent for various logical functions.
5. Describe digital, discrete and analog I/O and their applications.
6. Describe ladder logic, functional logic diagrams, function block, sequential function chart and script languages.
7. Describe basic troubleshooting techniques and safety considerations when working on PLC's.
8. Assemble a modular PLC using the basic components.
9. Program and demonstrate a discrete control logic circuit.
10. Program and demonstrate an analog control logic circuit.

G. Introduction to Data Communications ..... 10 Hours

Outcome: ***Describe the fundamentals of data communication.***

1. Describe terms used in data communication.
2. Explain serial data stream frame structure.
3. Explain the characteristics and applications of various transmission media.
4. Explain the characteristics and applications of various protocols.
5. Illustrate NULL Modem and straight through cabling.
6. Describe the purpose and application of Modems.
7. Connect two data communication devices and verify communication between them.
8. Analyze a digital waveform imposed on an analog signal using an oscilloscope and hand held communicator.

H. Introduction to Personal Computers ..... 2 Hours

Outcome: ***Describe the components and applications of a personal computer.***

1. Identify the essential hardware components of a computer.
2. Explain the purpose of data communication hardware.
3. Describe application software.
4. Demonstrate the ability to copy files, view and organize directories and backup data.

I. Office Applications ..... 4 Hours

Outcome: ***Use computer office applications.***

1. Describe office application software for personal computers.
2. Demonstrate the use of word processing package applications.
3. Demonstrate the use of spread sheet package applications.
4. Demonstrate the use of data base package applications.
5. Demonstrate the use of the internet to research technical information.

J. Industrial Software Applications ..... 4 Hours

Outcome: ***Use industrial software packages.***

1. Describe software packages for industrial applications.
2. Describe software used in maintenance and reliability management.
3. Demonstrate the installation, upgrading and removal of industrial software.
4. Describe troubleshooting techniques for problems with industrial software.

SECTION FOUR: .....PROCESS EQUIPMENT AND ENERGY SYSTEMS..... 73 HOURS

A. Drawing and Symbols ..... 6 Hours

Outcome: ***Identify standard drawings and symbols used in instrumentation.***

1. Define symbols used by ISA.
2. Describe the ISA identification system used in instrument drawings.
3. Define symbols used by SAMA.
4. Describe the SAMA identification system used for boiler control drawings.
5. Interpret P&ID drawings.
6. Interpret PFD drawings.
7. Develop and sketch a P&ID drawing.

B. Gas Compression ..... 8 Hours

Outcome: ***Describe the fundamental components and operation of gas compression.***

1. Describe the components of a reciprocating gas compressor.
2. Describe the components of other positive displacement compressors.
3. Describe the components of centrifugal gas compressors.
4. Describe the application of different gas compressors.
5. Describe the types of drivers used to drive compressors and pumps.
6. Identify the hazards associated with gas compression equipment.
7. Develop and sketch a P&ID of a compressor and the related process equipment.

C. Liquid Pumping ..... 4 Hours

Outcome: ***Describe the fundamental components and operation of liquid pumping.***

1. Describe the components of positive displacement pumps.
2. Describe the components of centrifugal pumps.
3. Describe the application of different pumps.
4. Describe the use of Variable Speed Drives (VSD) in the use of liquid pumping.
5. Identify the hazards associated with pumping equipment.
6. Develop and sketch a P&ID of a pump and the related process equipment.

D. Solids and Liquids ..... 4 Hours

Outcome: ***Describe the basic principles and equipment used for solids size reduction, solids enlargement, solids and liquids separation or mixing.***

1. Define size reduction in regards to crushing, grinding and pulverizing.
2. Explain the process of size enlargement of material.
3. Describe size separation and screening for process materials.
4. Describe the principles and operation of two and three phase separators.
5. Explain auxiliary support equipment/processes.
6. Describe equipment used to maintain material consistency.

E. Heat Transfer and Evaporation ..... 5 Hours

Outcome: ***Describe the principles and application of heat transfer and evaporation.***

1. Describe the terms of heat transfer.
2. Describe heat exchangers.
3. Describe cooling methods.
4. Describe process evaporators.
5. Describe the operation of a multiple effect evaporator.
6. Describe the separation of solids and liquids by crystallization.

F. Drying, Humidification and Dehumidification ..... 5 Hours

Outcome: ***Describe the principle and application used in the processes of gas humidification, gas drying (dehumidification), and solids drying.***

1. Define the terms of drying, humidification and dehumidification.
2. Describe the processes of solids drying.
3. Describe humidification of process gases.
4. Describe dehumidification of process gases.
5. Describe the principles and applications of absorption, desorption and adsorption.
6. Describe the principle of operation of desiccant and chemical dehydration processes.

G. Distillation and Fractionation ..... 3 Hours

Outcome: ***Describe the principles and application used in the process of fractionation and distillation.***

1. Define the terms used in distillation and fractionation processes.
2. Describe the distillation process.
3. Describe the fractionation process.

H. Boilers and Direct Fired Heaters ..... 3 Hours

Outcome: ***Describe the principle and application of boilers and fired heaters.***

1. Describe boilers and auxiliary equipment.
2. Describe boiler controls.

3. Describe burner management.
4. Describe direct fired heaters.

I. Production and Processing Plants ..... 5 Hours

Outcome: ***Explain the major components and processes of process facilities using process flow diagrams (PFD).***

1. Use a PFD to explain the major processes, flows and unit operations for gas sweetening and sulphur recovery.
2. Use a PFD to explain the major processes, flows and unit operations for NGL/LPG recovery and fractionation.
3. Use a PFD to explain the major processes, flows and unit operations for a Kraft pulp and paper mill.
4. Use a PFD to explain the major processes, flows and unit operations for an oil upgrading facility.
5. Use a PFD to explain the major processes, flows and unit operations for an oil refinery.

J. Gas Detection ..... 8 Hours

Outcome: ***Select, install, and maintain gas detection devices.***

1. Describe the application of personal, portable and fixed gas detectors.
2. Describe the placement of portable and fixed gas detectors.
3. Describe the application of combustible gas detectors.
4. Describe the selection of calibration gas for an application.
5. Describe the application of toxic gas detectors.
6. Calibrate a combustible gas detector selecting calibration gases.
7. Calibrate a H_2S gas detector selecting calibration gases.
8. Perform and document a bump test and calibration of a personal multi-gas monitor.

K. Fire and Smoke Detection ..... 4 Hours

Outcome: ***Select, install, and maintain fire and smoke detection devices.***

1. Describe the applications of fire and smoke detectors.
2. Describe the various types of fire detectors stating their operating characteristics, advantages and limitations.
3. Describe the various types of smoke detectors stating their operating characteristics, advantages and limitations.
4. Test a smoke detector.

L. Emergency Shutdown Systems ..... 3 Hours

Outcome: ***Describe Emergency Shutdown Systems (ESD).***

1. Explain the need for ESD systems.
2. Describe the components and logic of an ESD System.
3. Explain the applications of ESD systems.
4. Describe the individual responsibility after the activation of an ESD system.

M. Relieving Devices ..... 3 Hours

Outcome: ***Describe relieving devices.***

1. Explain the need for relieving devices.
2. Describe the various types of relieving devices stating their operating characteristics, advantages and limitations.
3. Describe the documentation and governing body/certification requirements for relieving devices.

N. Pneumatic Systems ..... 8 Hours

Outcome: ***Describe the components and applications of pneumatic supplied systems.***

1. Describe the safety considerations of pneumatic systems.
2. Describe and illustrate the various types of air compressors and their applications.
3. Describe and illustrate air dryers, air receivers and air distribution piping as part of the overall instrument air system.
4. Describe alternate gas supplies used in pneumatic systems and related hazards.
5. Describe quality, specifications and sizing of an instrument air system.
6. Describe the benefits and disadvantages of pneumatic systems compared to other energy systems.

O. Hydraulic Systems ..... 2 Hours

Outcome: ***Describe the fundamentals and applications of hydraulic systems.***

1. Describe the safety and environmental considerations of hydraulic systems.
2. Describe and illustrate the specifications and components of a hydraulic system.
3. Describe alternate fluids used in hydraulic systems and related hazards.
4. Describe the benefits and disadvantages of hydraulic systems compared to other energy systems.

P. Electrical Systems ..... 2 Hours

Outcome: ***Describe the fundamentals and applications of electrical systems.***

1. Describe the safety considerations of electrical energy system.
2. Describe the components of alternate/multiple power sources and associated hazards.
3. Describe the benefits and disadvantages of electrical systems compared to other energy systems.

THIRD PERIOD TECHNICAL TRAINING
INSTRUMENTATION TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ELECTRONIC INSTRUMENT LOOPS..... 43 HOURS

A. Analog Loops ..... 10 Hours

Outcome: ***Describe the fundamentals and applications of analog loops.***

1. Describe the standard signal levels used in industrial measurement and control loops.
2. Describe why current rather than voltage is primarily used for signal transmission.
3. Describe the current to voltage relationships of an analog measurement loop.
4. Describe the current to voltage relationships of an analog control loop.
5. Describe test procedures used to calibrate and/or troubleshoot analog loops.
6. Calculate maximum loop resistance for a current loop.
7. Describe the circuits used to test the output of a transmitter without interrupting the current flow.
8. Predict how the loop could be affected by common circuit faults.
9. Calculate loop output between various standards.
10. Illustrate an instrument loop using a 2 wire transmitter.
11. Illustrate an instrument loop using a 4 wire transmitter.
12. Demonstrate procedures used to calibrate an analog loop.

B. Grounding and Shielding Methods ..... 8 Hours

Outcome: ***Describe the purpose and principles of grounding and shielding.***

1. Describe the importance of grounding and shielding electronic equipment.
2. Describe the difference between grounding and shielding.
3. Describe methods for grounding electronic equipment.
4. Describe methods for shielding electronic equipment.
5. Install an analog instrument, demonstrate shielding methods and compare unshielded and shielded wiring methods using an oscilloscope.
6. Install an analog instrument, demonstrate grounding methods and compare ungrounded and grounded wiring methods using an oscilloscope and multimeter.

C. Analog to Digital and Digital to Analog Conversion ..... 4 Hours

Outcome: ***Describe analog to digital (ADC) and digital to analog converters (DAC).***

1. Describe the purpose and application for both ADC's and DAC's:
2. Explain terms and specifications for both ADC's and DAC's.
3. Describe multiplexer applications.

4. Describe resolution and calculate the resolution based on the number bits of binary data.
5. Perform output calculations of a ADC and DAC for a given input value.

D. Signal Conditioning ..... 6 Hours

Outcome: ***Select, install, and maintain signal conditioners.***

1. Describe the functions and applications of signal transducers.
2. Identify signal transducers.
3. Describe the components, function and application of a current to pressure (I/P) transducer.
4. Install and calibrate an I/P signal transducer.

E. Smart Instruments ..... 10 Hours

Outcome: ***Select, install, and maintain smart instruments.***

1. Describe the hardware architecture, features and operation of smart instruments.
2. List the digital communications standards and protocols used with smart instruments.
3. Describe the operation of hand-held and personal computer interfaces used with smart instruments.
4. Describe the advantages of smart instruments in measurement and control loops.
5. Install and configure a smart positioner and capture a valve signature.
6. Configure and verify the accuracy of a smart thermocouple temperature transmitter.
7. Configure and verify the accuracy of a smart RTD temperature transmitter.

F. Single Loop Digital Controllers ..... 5 Hours

Outcome: ***Select, install, and maintain single loop digital controller (SLDC).***

1. Describe the operation of SLDC.
2. Describe the functions and applications of SLDC.
3. Sketch a control loop diagram illustrating controller type, action and valve fail position.
4. Connect and configure a SLDC for a level control application.

SECTION TWO: ..... MEASUREMENT ..... 74 HOURS

A. Accuracy and Repeatability ..... 9 Hours

Outcome: ***Calculate the accuracy of a measurement system.***

1. Describe accuracy and its importance in measurement.
2. Describe repeatability and its importance in measurement.
3. Describe the correlation of accuracy and repeatability as they relate to measurement uncertainty.
4. State accuracy statements for analog and digital instruments and calculate their possible range of errors.
5. Demonstrate the accuracy and repeatability of a given instrument/component from the values measured and then compared to the manufacturer's specifications.

6. Measure and calculate the possible and probable range of errors for a measurement system consisting of several instruments.
7. Verify and compare the accuracy of a thermocouple and a RTD at three points.

B. Measurement Traceability ..... 4 Hours

Outcome: ***Describe the importance of measurement traceability.***

1. Describe traceability and its importance in measurement and related certification.
2. Describe the regulatory standards and the governing bodies responsible for measurement accuracy and traceability.
3. Describe how measurement traceability relates to regulatory standards.
4. Research current regulations on measurement accuracy and traceability.

C. Differential Pressure ..... 4 Hours

Outcome: ***Describe differential pressure as it relates to level and density measurement.***

1. Describe the differential pressure methods used in level measurement.
2. Describe the differential pressure methods used in density measurement.
3. Describe wet and dry leg level transmitter installations.
4. Describe remote seal leg level transmitter installations.
5. Calculate the expected zero and span in a wet leg level application, install and configure a smart differential pressure transmitter for a suppressed zero application and verify the calculations.
6. Connect and configure a smart differential pressure transmitter in a wet leg suppressed zero application and determine the density.

D. Nuclear ..... 3 Hours

Outcome: ***Describe nuclear instruments used in density and level measurement.***

1. Describe the required safety considerations when working with and around radioactive sources.
2. Describe the principles and applications used in nuclear instruments.
3. Describe the installation requirements for nuclear instruments.
4. Describe the methods used to calibrate nuclear instruments.
5. Describe the regulatory bodies for nuclear sources.

E. Ultrasonic and Radar ..... 5 Hours

Outcome: ***Select, install, and maintain ultrasonic and radar level instruments.***

1. Describe the principles and application of ultrasonic level instruments.
2. Describe the installation requirements for ultrasonic level instruments.
3. Describe the principles and application of radar level instruments.
4. Describe the installation requirements for radar level instruments.
5. Connect and calibrate an ultrasonic or radar level instrument.

F. Capacitance/Thermal Dispersion/Optical/Magnetostrictive ..... 5 Hours

Outcome: ***Select, install, and maintain capacitance, thermal, optical, and magnetostrictive level instruments.***

1. Describe the principles, application and installation requirements of capacitance level instruments.
2. Describe the principles, application and installation requirements of thermal level instruments.
3. Describe the principles, application and installation requirements of optical level instruments.
4. Describe the principles, application and installation requirements of magnetostrictive level instruments
5. Connect and calibrate a capacitance level instrument.

G. Solids ..... 2 Hours

Outcome: ***Select, install, and maintain solids level instruments.***

1. Describe the principles and application of solids level instruments.
2. Describe the installation requirements for solids level instruments.

H. Flow Measurement ..... 4 Hours

Outcome: ***Describe flow measurement.***

1. State the purposes for flow measurement.
2. Compare mass flow and volumetric flow.
3. Describe the regulatory standards and the governing bodies responsible for flow measurement.
4. Describe the principles and application of meter proving.
5. Sketch a loop diagram illustrating basic components of a proving measurement system.

I. Differential Pressure Elements ..... 3 Hours

Outcome: ***Select, install, and maintain differential pressure elements.***

1. Describe the principles and applications of differential pressure elements.
2. Describe the advantages and limitations of differential pressure elements
3. Describe the components of differential pressure elements.
4. Describe the installation requirements for differential pressure elements.
5. Describe the maintenance and calibration of differential pressure elements.

J. Magnetic Flow Meters ..... 3 Hours

Outcome: ***Select, install, and maintain magnetic flow meters.***

1. Describe the principles and applications of magnetic flowmeters.
2. Describe the advantages and limitations of magnetic flowmeters
3. Describe the components of a magnetic flowmeter.
4. Describe the installation requirements for magnetic flowmeters.
5. Describe the maintenance and calibration of magnetic flowmeters.

K. Turbine Flow Meters ..... 6 Hours

Outcome: ***Select, install, and maintain turbine flow meters.***

1. Describe the principles and applications of turbine flowmeters.
2. Describe the advantages and limitations of turbine flowmeters
3. Describe the components of a turbine flowmeter.
4. Describe the installation requirements for turbine flowmeters.
5. Describe the maintenance and calibration of turbine flowmeters.
6. Perform a volumetric prove of a turbine flow meter calculating the "K" factor and configure the totalizer.

L. Vortex Flow Meters ..... 3 Hours

Outcome: ***Select, install, and maintain vortex flow meters.***

1. Describe the principles and applications of vortex flowmeters.
2. Describe the advantages and limitations of vortex flowmeters
3. Describe the components of a vortex flowmeter.
4. Describe the installation requirements for vortex flowmeters.
5. Describe the maintenance and calibration of vortex flowmeters.

M. Ultrasonic Flow Meters ..... 3 Hours

Outcome: ***Select, install, and maintain ultrasonic flow meters.***

1. Describe the principles and applications of ultrasonic flowmeters.
2. Describe the advantages and limitations of ultrasonic flowmeters.
3. Describe the components of an ultrasonic flowmeter.
4. Describe the installation requirements for ultrasonic flowmeters.
5. Describe the maintenance and calibration of ultrasonic flowmeters.

N. Mass Flow Meters ..... 6 Hours

Outcome: ***Select, install, and maintain mass flow meters.***

1. Describe the principles and applications of mass flowmeters.
2. Describe the advantages and limitations of mass flowmeters.
3. Describe the components of a mass flowmeter.
4. Describe the installation requirements for mass flowmeters.
5. Describe the maintenance and calibration of mass flowmeters.
6. Configure a mass flow meter, perform a master meter prove and calculate the meter factor.

O. Positive Displacement ..... 6 Hours

Outcome: ***Select, install, and maintain positive displacement flow meters.***

1. Describe the principles and applications of positive displacement flowmeters.
2. Describe the advantages and limitations of positive displacement flowmeters.
3. Describe the components of a positive displacement flowmeter.
4. Describe the installation requirements for positive displacement flowmeters.
5. Describe the maintenance and calibration of positive displacement flowmeters.
6. Connect and determine meter factor for a positive displacement flow meter in a gas application.

P. Flow Computers ..... 8 Hours

Outcome: ***Select, install, and maintain flow computers.***

1. Describe the principles and applications of flow computers.
2. Describe the advantages and limitations of flow computers.
3. Describe the components of flow computers.
4. Describe the parameters of a flow computer.
5. Connect a flow computer for a liquid application to an ultrasonic meter and configure.
6. Install end devices on a gas orifice meter run, connect to a flow computer, configure and calibrate measurement system.

SECTION THREE: ..... PHYSICAL PROPERTIES ..... 66 HOURS

A. Matter ..... 9 Hours

Outcome: ***Describe the relationship between atomic structure and electron flow.***

1. Describe the basic composition of matter.
2. Describe the basic structure of the atom.
3. Describe the periodic table as it applies to properties of matter.
4. Describe physical and chemical changes to matter.
5. Describe nuclear fission and fusion.

B. Inorganic Compounds ..... 8 Hours

Outcome: ***Describe inorganic compounds.***

1. Describe the formation of compounds.
2. Describe oxidation.
3. Describe simple and complex ions.
4. Describe cation/anion combinations.
5. Describe the classifications of compounds.

C. Chemical Calculations ..... 8 Hours

Outcome: ***Demonstrate chemical calculations.***

1. Describe molar mass, mass, number of molecules and number of atoms for a given number of moles of any compound.
2. Calculate the volume for a given number of moles of any gas at standard conditions.
3. Calculate the percent mass composition of each element in a compound.
4. Describe concentration of solutions.
5. Balance formulas for chemical reactions.

D. Chemical Reaction ..... 12 Hours

Outcome: ***Describe chemical reaction.***

1. Describe the classification of chemical reactions.
2. Describe the factors that influence rate of chemical reaction.
3. Describe chemical reactions involving metal and a metal ion.
4. Describe exothermic and endothermic reaction.
5. Describe activation energy and reaction rate.
6. Describe the electrical properties of water solutions.
7. Define pH, "hydrogen ion concentration", and ionic activity.
8. Describe acids and bases as related to the pH scale.
9. Describe acid/base titration.
10. Describe oxidization and reduction in a chemical reaction.
11. Describe electrochemical cells.
12. Perform acid/base titration.

E. Organic Chemistry ..... 15 Hours

Outcome: ***Describe organic chemistry.***

1. Describe carbon bonding.
2. Describe carbon compounds and their molecular formula.
3. Describe organic families.
4. Describe the hydro carbon chain.
5. Describe the chemical reactions used to refine the hydro carbon chain.
6. Apply the stoichiometric equation to combustion of hydro carbons.

F. Viscosity ..... 2 Hours

Outcome: ***Describe viscosity.***

1. Describe absolute viscosity and kinematic viscosity.
2. Describe Newtonian and non-Newtonian liquids.
3. Describe the effect of viscosity on flow measurement.

G. Metallurgy ..... 12 Hours

Outcome: ***Select a metal or alloy for a required application.***

1. Describe the physical and mechanical properties of metals.
2. Describe the applications and mechanical properties of alloying elements used in steel.
3. Identify the effects of heat treatment on metals.
4. Describe the techniques of conditioning and coating of metals and alloys.
5. Describe the effects of expansion and contraction.
6. Describe the physical and mechanical properties of metal and alloys and the factors that change these properties.
7. Interpret charts and tables to select a metal or alloy for an application.
8. Describe methods of destructive and non destructive testing of metals.
9. Describe hydrostatic tests.
10. Describe hardness testing.

SECTION FOUR: ..... PROCESS ANALYZERS ..... 48 HOURS

A. Process Analyzers ..... 6 Hours

Outcome: ***Explain the terminology, technology, and applications of analytical measurements.***

1. Describe process analytical measurement and terminology.
2. Describe applications of process analyzers.
3. Describe analyzer technologies.
4. Describe analyzer tolerances and limitations.
5. Describe the environmental considerations for analyzer installations.
6. Describe calibration and calibration interaction of process analyzers.
7. Describe qualitative and quantitative data analysis.
8. Interpret block diagrams used in analyzer documentation.

B. Analyzer Sampling Systems ..... 8 Hours

Outcome: ***Explain analyzer sampling systems, including the system components and materials specifications.***

1. Describe the purpose of a sample system.
2. Describe components, design and limitations of sample systems.
3. Describe the importance of sample loop time.
4. Describe the purpose and methods of sample conditioning.
5. Define clean and dirty service sample systems.
6. Define in-situ and extractive sampling, used by continuous analyzers.
7. Describe representative "grab" sampling and the techniques utilized in "grab" sampling.
8. Describe common troubleshooting techniques of various sample systems.

C. Gas Analyzers ..... 12 Hours

Outcome: ***Select, install, and maintain gas analyzers.***

1. Describe applications of gas analyzers.
2. Describe safety concerns when dealing with gas analyzers.
3. Describe the principles of analysis and application of relative humidity analyzers.
4. Perform relative humidity calculations using psychometric charts and tables.
5. Describe the principles of analysis and application of dew point analyzers.
6. Describe the operation and calibration for dew point sensors.
7. Describe the principles of analysis and application of moisture analyzers.
8. Describe the principles of analysis and application of oxygen analyzers.
9. Describe the principles of analysis and application of combustion analyzers.
10. Describe combustible chemical reactions.
11. Describe combustion parameters measured to determine air to fuel ratio.
12. Outline the relationship between energy conservation, pollution emissions and combustion efficiency.
13. Connect / calibrate a combustion analyzer and demonstrate the effect of changing air / fuel ratios.

D. Liquid Analyzers ..... 12 Hours

Outcome: ***Select, install and maintain liquid analyzers.***

1. Describe applications of liquid analyzers.
2. Describe safety concerns when dealing with liquid analyzers.
3. Describe the principles of analysis and application of pH analyzers.
4. Describe the electrochemical process, measurement and reference half-cell reactions.
5. Apply the Nernst equation to pH measurements and determine why temperature correction is required.
6. Discuss pH sensor limitations and control problems.
7. Describe similarities and differences between pH, specific ion and ORP measurements.
8. Describe buffer solutions for pH standards.
9. Describe the principles of analysis and application of conductivity analyzers.
10. Describe the operation of conductivity cells.
11. Describe the principles of analysis and application of turbidity analyzers.
12. Describe the operation of turbidity analyzers.
13. Describe the principles of analysis and application of dissolved oxygen analyzers.
14. Describe the operation of dissolved oxygen analyzers.
15. Connect / calibrate a pH analyzer using 3 points and demonstrate the effects of buffer temperature on calibration.

E. Physical Property Analyzers ..... 6 Hours

Outcome: ***Select, install and maintain physical property analyzers.***

1. Describe the principles of analysis and application of distillation (boiling point) analyzers.

2. Describe the principles of analysis and application of vapour pressure analyzers.
3. Describe the principles of analysis and application of viscosity analyzers.
4. Describe the principles of analysis and application of density analyzers.
5. Demonstrate the effect of temperature on vapour pressure.

F. Vibration Monitoring ..... 4 Hours

Outcome: ***Select, install, and maintain vibration monitoring.***

1. Describe vibration as it relates to force and motion.
2. Describe the units of measurement related to vibration monitoring.
3. Describe where vibration monitoring is commonly used.
4. Describe the components of vibration monitoring equipment.
5. Assemble a probe, cable and amplifier, conduct a vibration analysis on various ferrous and nonferrous targets and interpret the results to establish alarm and trip points.

SECTION FIVE: ..... PROCESS CONTROL ..... 69 HOURS

A. Closed Loop Control ..... 16 Hours

Outcome: ***Explain the principle and application of closed loop control for process control.***

1. Describe open loop control.
2. Describe block diagrams and output/input equations for open loop control.
3. Describe a closed loop controller.
4. Describe the applications and limitations of closed loop control.
5. Describe block diagrams and output/input equations for closed loop control.
6. Describe direct and reverse acting controllers and determine a method for setting controller action.
7. Describe variables related to control.
8. Describe the PID control algorithm.
9. Describe the selection and function of controller modes.
10. Describe controller bias.
11. Perform an open loop test of a P+I controller.

B. Process Loop Dynamics ..... 16 Hours

Outcome: ***Describe the dynamics of process control loops.***

1. Describe period of oscillation for a control loop.
2. Describe dead time (time constant) as it relates to control loop.
3. Describe the effect of a step input to a capacity element.
4. Describe the characteristics of gain and phase for a single capacity system.
5. Describe the relationship between a multi-capacity system and the equivalent dead time and single capacity system.
6. Describe the method of reducing a general multi-capacity system to equivalent dead time and single capacity system.
7. Describe self regulation and its significance in process control.

8. Describe the characteristics of an integrating process.
9. Describe the concept of offset for an integrating process.
10. Describe the phase relationship for an integrating process.
11. Explain control of a selected integrating process.

C. Control Loop Analysis ..... 10 Hours

Outcome: ***Describe the methods used to analyze loop characteristics.***

1. Describe the relationship between loop response to controller mode selection.
2. Describe the difference between setpoint and load change to system response.
3. Describe the open and closed loop gains for a system.
4. Describe the difference between linear and non-linear system gains.
5. Describe control strategies for non-linear system gains.
6. Sketch the loop statics diagram for a temperature loop, compute static gains and verify in a control loop.
7. Sketch the loop statics diagram for a flow loop, compute static gains and verify in a control loop.
8. Develop a general equation for closed loop steady state.

D. Digital Controller Tuning ..... 10 Hours

Outcome: ***Describe the fundamentals of digital controller tuning.***

1. Describe the features and functionality of digital controllers versus pneumatic controllers.
2. Determine controller mode selection and initial settings for various process control loops.
3. Calculate the controller settings of a control loop. Using the self tuning feature of an digital controller verify results.
4. Connect, configure and tune a single loop digital controller in a gas pressure process.
5. Connect, configure and tune a single loop digital controller in a liquid pressure process.
6. Connect, configure and tune a controller in a flow application.
7. Connect, configure and tune a controller in a level application.

E. Cascade Control ..... 10 Hours

Outcome: ***Describe the principles, application and operation of cascade control loops.***

1. Describe the advantages and applications for cascade control.
2. Describe failure mode considerations and control action for cascade control loops.
3. Explain how the effective time constant of the inner loop is reduced under cascade control.
4. Describe the methods for tuning cascade control systems.
5. Draw a block diagram of a cascade control system.
6. Connect and tune a cascade control loop for a level/flow application.

F. Selective Control ..... 7 Hours

Outcome: ***Describe the principles, application and operation of selective control loops.***

1. Describe the advantages and applications for selective control.

2. Explain how to prevent reset windup on selective control.
3. Describe the methods for tuning selective control systems.
4. Draw a block diagram of a selective control system.
5. Configure and tune a selective control loop.

FOURTH PERIOD TECHNICAL TRAINING
INSTRUMENTATION TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ADVANCED PROCESS CONTROL..... 78 HOURS

A. Multi Variable Control ..... 8 Hours

Outcome: ***Describe the principles, application and operation of multi variable control loops.***

1. Describe the advantages and applications for multi variable control.
2. Describe the methods for tuning multi variable control systems.
3. Draw a block diagram of a multi variable control system.
4. Configure and tune a multi variable control loop.

B. Ratio Control ..... 8 Hours

Outcome: ***Describe the principles, application and operation of ratio control loops.***

1. Describe the advantages and applications for ratio control.
2. Describe the methods for tuning ratio control systems.
3. Draw a block diagram of a ratio control system.
4. Configure and tune a ratio control using hot and cold streams.

C. Feed Forward Control ..... 10 Hours

Outcome: ***Describe the principles, application and operation of feed forward control loops.***

1. Describe the advantages and applications for feed forward control.
2. Describe the methods for tuning feed forward control systems.
3. Draw a block diagram of a feed forward control system.
4. Configure and tune a feed forward control loop
5. Demonstrate the differences between a feed forward control loop and a feed back control loop.

D. Split Range Control ..... 6 Hours

Outcome: ***Describe the principles, application and operation of split range control loops.***

1. Describe the advantages and applications for split range control.
2. Describe the methods for tuning split range control systems.
3. Draw a block diagram of a split range control system.
4. Configure and tune a split range control loop.

E. Distillation Control ..... 12 Hours

Outcome: ***Describe the application of control strategies used in the distillation process.***

1. Describe the control strategies used in the distillation process.
2. Define the terms related to distillation process control.

3. Describe common problems associated with distillation process control.
4. Demonstrate distillation process control.

F. Boiler Control ..... 12 Hours

Outcome: ***Describe the application of control strategies used in the boiler process.***

1. Describe the control strategies used in the boiler process.
2. Define the terms related to boiler process control.
3. Describe common problems associated with boiler process control.
4. Demonstrate boiler process control.

G. Compressor Control ..... 12 Hours

Outcome: ***Describe the application of control strategies used in compressor control.***

1. Describe the control strategies used in centrifugal compressor control.
2. Define the terms related to centrifugal compressor control.
3. Describe common problems associated with centrifugal compressor control.
4. Describe the control strategies used in reciprocating compressor control.
5. Define the terms related to reciprocating compressor control.
6. Describe common problems associated with reciprocating compressor control.
7. Demonstrate reciprocating and centrifugal compressor control applications.

H. Safety Instrumented Systems (SIS) ..... 10 Hours

Outcome: ***Describe the principles and applications of Safety Instrumented Systems (SIS).***

1. Describe Safety Instrumented Systems (SIS).
2. Describe Safety Integrity Level (SIL) ratings.
3. Describe redundancy as it relates to SIS.
4. Select, configure and verify a SIS system for a specific SIL rating.

SECTION TWO: ..... COMMUNICATION ..... 48 HOURS

A. Signal Transmission Systems ..... 6 Hours

Outcome: ***Select, install and maintain signal transmission systems.***

1. Describe signal transmission systems used for communication.
2. Describe the applications of signal transmission systems.
3. Describe the components of signal transmission systems.
4. Connect and configure a signal transmission system.

B. Communication Signal Converters ..... 6 Hours

Outcome: ***Select, install and maintain communication signal converters.***

1. Describe communication signal converters used for signal transmission.
2. Describe the applications of signal converters.

3. Describe the components of signal converters.
4. Configure a signal converter.

C. Protocols ..... 10 Hours

Outcome: ***Describe protocols of communication systems.***

1. Describe and compare the capabilities of digital field devices to that of analog devices.
2. Compare open and proprietary communication protocols.
3. Describe communication devices and application software.
4. Connect, configure and analyze several different protocol signals between devices.

D. Industrial Networks ..... 10 Hours

Outcome: ***Select, install and maintain industrial networks.***

1. Describe the different area networks and their applications.
2. Describe network components and characteristics.
3. Describe different transmission techniques.
4. Describe the different network topologies.
5. Assemble and configure a wireless network.

E. Supervisory Control and Data Acquisition (SCADA) ..... 16 Hours

Outcome: ***Select, install and maintain Supervisory Control and Data Acquisition systems.***

1. Describe SCADA applications.
2. Describe the components and installation considerations of SCADA systems.
3. Describe the standards, codes and licenses associated with SCADA systems.
4. Assemble, configure and test a single point to point SCADA system.
5. Assemble, configure and test a SCADA host to multiple Remote Terminal Units (RTU).

SECTION THREE: ..... CONTROL SYSTEMS ..... 113 HOURS

A. Programmable Logic Controllers (PLC) ..... 47 Hours

Outcome: ***Select, install and maintain Programmable Logic Controllers (PLC).***

1. Describe programming languages used in PLC's.
2. Describe methods of networking PLC's.
3. Describe redundancy as it applies to PLC's.
4. Describe change management as it applies to PLC program changes.
5. Describe software versions and updates.
6. Describe safety considerations when forcing, disabling and bypassing I/O's.
7. Select all of the components, assemble and configure PLC's for an industrial network application.
8. Connect and program a PLC using function blocks in a process control application.
9. Connect and program a PLC using mixed programming in a process control application.
10. Connect and network PLC's to implement an industrial application.
11. Add I/O to a PLC, perform a program change and backup.

12. Integrate multiple control devices to a PLC.
13. Use a configuration compare tool and update PLC change documentation.

B. Distributed Control Systems (DCS) ..... 50 Hours

Outcome: ***Select, install and maintain Distributed Control Systems (DCS).***

1. Describe DCS and their applications.
2. Describe the components of a DCS.
3. Describe redundancy as it applies to DCS.
4. Describe alarm management concepts.
5. Describe software versions and updates.
6. Describe change management as it applies to DCS program changes.
7. Describe safety considerations when forcing, disabling and bypassing I/O's
8. Connect and program a DCS for a process control application using an advanced control strategy.
9. Configure and assign trends and tune loops for a multi loop system.
10. Add a smart field device to a DCS, configure and prioritize alarms and commission.
11. Integrate multiple control devices to a DCS.
12. Add I/O to a DCS, perform a program change and backup.
13. Troubleshoot a fault on a DCS using error codes.
14. Use historical logs and diagnostic tools to verify changes and troubleshoot errors.

C. Variable Speed Drives (VSD) ..... 6 Hours

Outcome: ***Describe Variable Speed Derives (VSD) used in process control.***

1. Describe the principles and applications of VSDs.
2. Describe components of VSDs.
3. Describe software versions and updates.
4. Connect and configure a VSD to a PLC to control a process.

D. Human Machine Interfaces (HMI) ..... 10 Hours

Outcome: ***Select, install and maintain Human Machine Interfaces (HMI).***

1. Describe HMI components and their applications.
2. Describe programming/configuration software used for HMIs.
3. Describe methods of networking HMIs.
4. Describe software versions and updates.
5. Describe change management as it applies to HMI program changes.
6. Connect and program a HMI in a process control application.
7. Configure an HMI for VSD flow control.
8. Perform a program change and backup.

SECTION FOUR:PROCESS ANALYZERS / MAINTENANCE PLANNING / WORKPLACE SKILLS ... 61 HOURS

A. Process Chromatography ..... 12 Hours

Outcome: ***Select, install and maintain chromatographs.***

1. Explain the principle of analysis utilized by chromatography.
2. Define the terminology used in chromatography.
3. Describe the hazards and safe work practises related to chromatography and their sample systems.
4. Describe sample systems and sample conditioning as they apply to chromatography.
5. Describe the components of a gas chromatograph.
6. Describe detectors used in gas chromatography.
7. Describe the components of a liquid chromatograph.
8. Describe detectors used in liquid chromatography.
9. Explain multi stream sample switching techniques.
10. Perform a manufacturer's periodic maintenance routine on a gas chromatograph unit.
11. Select a column and assemble sample system components for a given sample stream for a gas chromatograph, run analysis and interpret results.

B. Mass Spectroscopy Measurement ..... 4 Hours

Outcome: ***Describe the principles, terminology, and applications of mass spectroscopy measurement.***

1. Describe the principles of mass spectroscopy measurement.
2. Describe the application of mass spectroscopy measurement.

C. Environmental Monitoring ..... 8 Hours

Outcome: ***Select, install and maintain environmental monitoring devices.***

1. Describe environmental monitoring and list pollutants that must be monitored and controlled.
2. Describe environmental monitoring with regards to health and safety.
3. Describe the role of government regulatory agencies.
4. Describe regulatory compliance with regard to environmental monitoring and the consequences of noncompliance.
5. Select and assemble sample system and sample conditioning components for a given sample stream for an environmental monitoring system, run analysis and interpret results.

D. Spectroscopic Analyzers ..... 3 Hours

Outcome: ***Select, install and maintain spectroscopic analyzers.***

1. Describe the electromagnetic spectrum and electro-magnetic radiation.
2. Describe the principles of analysis and application of spectroscopic analyzers.
3. Describe absorption and emission spectrums.
4. Describe the Beer-Lambert absorption laws to Infrared (I.R.) and Ultraviolet (U.V.) absorption analyzers.
5. Describe fluorescence and phosphorescence.

E. Infrared Analyzers ..... 6 Hours

Outcome: ***Select, install and maintain infrared analyzers.***

1. Describe the difference between dispersive infrared (DIR) and non dispersive infrared (NDIR) analyzers.
2. Describe the sources, cells and detectors utilized by NDIR analyzers.
3. Describe negative and positive filtering techniques as applied in industry.
4. Describe process applications for IR analyzers.
5. Demonstrate the operation and calibration of a NDIR analyzer.

F. Ultraviolet Analyzers ..... 6 Hours

Outcome: ***Select, install and maintain ultraviolet analyzers.***

1. Describe the principles of analysis and application of ultraviolet analyzers (UV).
2. Describe UV precautions and hazards.
3. Explain the differences between UV absorption and UV emission (fluorescence) analysis.
4. Describe the components of UV analyzers.
5. Demonstrate the operation and calibration of an ultraviolet analyzer.

G. Chemiluminescence ..... 6 Hours

Outcome: ***Select, install and maintain chemiluminescent analyzers.***

1. Describe the principles of analysis and application of chemiluminescent analyzers.
2. Describe the chemical reactions related to chemiluminescent analysis.
3. Describe the components of a chemiluminescent Nitric Oxide (NO) analyzer.
4. Assemble the components of a gas sample system for a chemiluminescence analyzer.
5. Demonstrate the operation and calibration of a chemiluminescence analyzer.

H. Maintenance Planning ..... 10 Hours

Outcome: ***Describe the responsibilities of a technician in the maintenance planning process.***

1. Describe reactive, preventative and predictive methods of maintenance planning.
2. Describe Key Performance Indicators (KPI) as it relates to reliability.
3. Describe the equipment criticality decision process as it relates to maintenance planning.
4. Describe the inventory control process.
5. Describe estimating, justification and purchasing procedures.
6. Describe maintenance scheduling and record keeping.

I. Workplace Coaching Skills ..... 2 Hours

Outcome: ***Display coaching skills.***

1. Describe coaching skills used for training apprentices.

J. Advisory Network ..... 2 Hours

Outcome: ***Describe the advisory network***

1. Explain the role and purpose of the advisory network, local apprenticeship committee, and provincial apprenticeship committee.

K. Interprovincial Standards ..... 2 Hours

Outcome: ***Discuss Red Seal / Interprovincial Standards***

1. Describe the National Occupational Analysis (NOA).
2. Describe the relationship between the NOA and Red Seal / Interprovincial examinations.
3. Discuss the roles of federal and provincial government in the development of Red Seal standards.
4. Discuss the role of industry in the development of Red Seal standards.
5. Explain the intent of the Red Seal exam as it relates to interprovincial mobility.
6. Describe sources of information on Red Seal standards and practice examinations.

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